Gram-Positive Cocci

Introduction

Gram-positive cocci come down to staph and strep. There are many species of staph and strep, but all gram-positive cocci are either staph or strep. You are expected to master three staphs and five streps.

It can be overwhelming to follow the laboratory diagnostic algorithm before you master the content. Reciting a litany of features as though every organism is unique is a waste of brainpower. Mnemonics that make no sense are a marker of failure. We'll show you a better way to do it, with simplification that doesn't sacrifice knowledge quality. Let's do this in words before we go through the algorithm. All gram-positive cocci are strep or staph. The first step is to see what kind of colonies these cocci are growing in and if they respond to the catalase test. All **staph is catalase positive** and **grows in clusters**; all **strep is catalase negative** and **grows in chains**. Therefore, the only possible findings are catalase-positive clusters (staph) and catalase-negative chains (strep).

Staph is further differentiated with coagulase—**coagulase-positive staph** is *Staph. aureus*. Coagulase-negative staph ("coag-neg staph") are contaminants and shouldn't be evaluated further. But because we CAN evaluate further, you have to know how to interpret that evaluation. The antibiotic test to distinguish between coag-neg staph species is **novobiocin**. *Staph. epidermidis* is sensitive to novobiocin, so it doesn't grow in the presence of novobiocin, whereas *Staph. saprophyticus* which is resistant to novobiocin, so it grows in the presence of novobiocin. You do not choose novobiocin for anything other than staph. You do not choose coagulase for anything but staph.

Strep is further differentiated by its hemolytic pattern on blood agar. There are three possible outcomes. If there is **complete** hemolysis, it is **β-hemolytic**. If there is **partial** hemolysis (turns red blood agar green), it is **α-hemolytic**. If there is no hemolysis, it is **γ-hemolytic**. The first category, **β-hemolytic** strep, has two species. When we want to distinguish between two species, we do an antibiotic test. Group A *Strep. pyogenes* (GAS, group A strep, and *Strep. pyogenes* are all acceptable ways of saying this, so we combine them) is **bacitracin sensitive**. Group B *Strep. agalactiae* (GBS, group B strep, and *Strep. agalactiae* are all acceptable ways to write this organism, so we combine them) is **bacitracin resistant**. You do not use bacitracin for any other strep category and do not use bacitracin on staph; only on **β-hemolytic** strep. The second category, α-hemolytic strep, has two species. The antibiotic used to differentiate between α-hemolytic strep species is optochin. *Strep. pneumo* is **optochin sensitive**, whereas viridans strep (a subgroup of α-hemolytic strep species) is **optochin resistant**. You only choose optochin for α-hemolytic strep; you do not use optochin for anything else. The third category, γ-hemolytic, might not actually be *Streptococcus* but rather *Enterococcus*, which was formerly considered part of group D strep alongside *Strep. bovis*. *Enterococcus* is a nasty little bugger and survives in everything. Confirmation is made by the ability to grow in bile and high-salt conditions.

Here it is again in pictographic form:

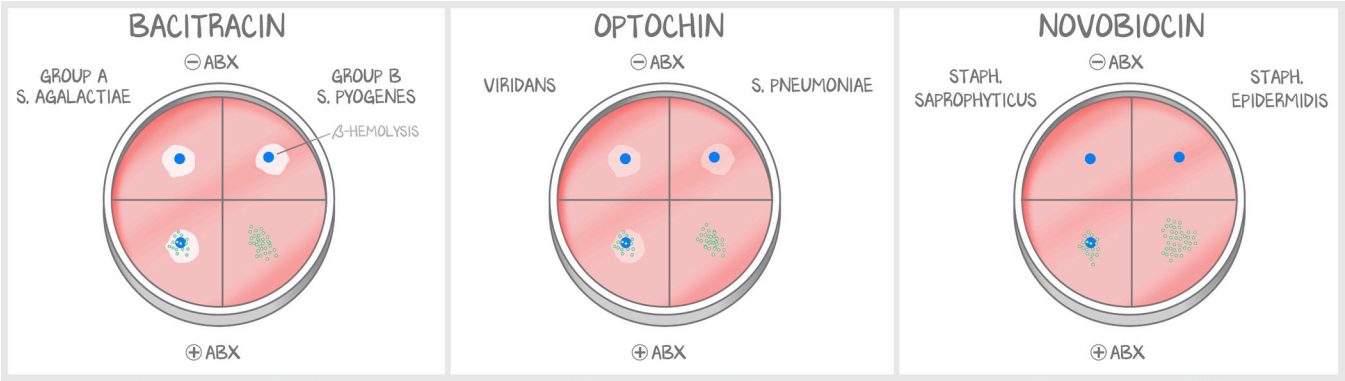

Figure 6.1: Antibiotic Testing
Antibiotic testing separates two species from one another. Both organisms demonstrate the same hemolytic pattern, but only one grows in the presence of the chosen antibiotic.

Here it is again in table form:

CULTURE AND CATALASE	SPECIES	COAGULASE	ANTIBIOTIC
Catalase positive and clusters	*Staph. aureus*	**Coagulase positive**	N/A
	Staph. saprophyticus	Coagulase negative	**Novobiocin resistant**
	Staph. epidermidis		**Novobiocin sensitive**

Table 6.1: Staph Species
From left to right, all staph is catalase positive and grows in clusters. *Staph. aureus* is coagulase positive. The others are separated by novobiocin sensitivity.

CULTURE AND CATALASE	HEMOLYSIS	SPECIES	ANTIBIOTIC	OTHER
Catalase negative and chains	β-hemolytic	Group A *Strep. pyogenes*	Bacitracin sensitive	N/A
		Group B *Strep. agalactiae*	**Bacitracin resistant**	N/A
	α-hemolytic	*Strep. pneumo*	Optochin sensitive	N/A
		Viridans strep	**Optochin resistant**	N/A
	γ-hemolytic	Group D strep, *Enterococcus*	N/A	Growth in bile or 6% NaCl

Table 6.2: Strep Laboratory Diagnosis
From left to right, all strep is catalase negative and grows in chains. A lack of hemolysis alone defines group D strep. β-Hemolytic is differentiated by bacitracin. α-Hemolytic is differentiated by optochin. The only thing you have to remember is, "Groups are β-hemolytic; group B = bacitracin resistant; the α-hemolytics are *Strep. pneumo* = optochin sensitive and viridans strep = optochin resistant; and γ-hemolytic is group D strep and *Enterococcus*."

For the rest of the lesson, we are going to go bug by bug, discussing their specific physiologies, any special proteins or toxins they have, and the diseases they commonly cause. We are approaching these diseases, these infections, from the perspective of microbiology, so the focus is on each bug. When we discuss organ systems, the diseases will arise again in greater detail than found here, with the emphasis on the disease process itself.

Before moving on, we want to instill a clinical paradigm that we will use here and again later in the organ systems—**staph grows down, strep grows out**. Regarding skin and soft tissue infections, the virulence factors of staph and strep species dictate how the organisms spread. Staph is hearty, has coagulase, and digests cells. It "grows down" in that it can burrow through the epidermis, dermis, and hypodermis. It gets from the skin down to the muscle and bone. In contrast, strep is dodgy, sneaky, and has hyaluronidase. This allows strep to degrade the connective tissue. Strep "grows out" because it can't go through the tissue layers, from the skin to the bone, but it can stay in the plane of infection and spread to a larger surface area. Strep goes out through the plane of infection; staph crosses tissue planes but doesn't generally spread far.

Staph. aureus

Follow along with Table 6.1, using it as a visual representation of the things discussed.

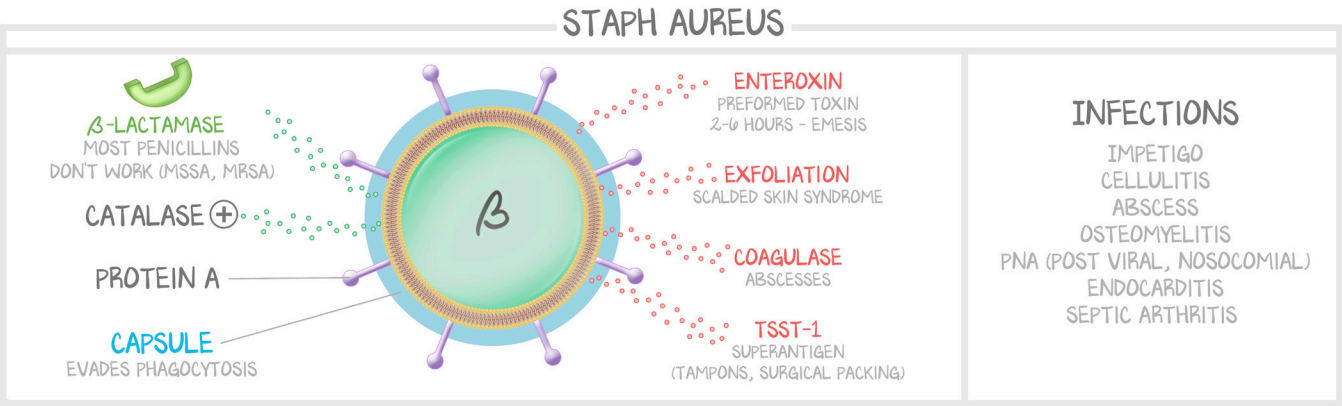

Figure 6.2: Staph
Staph. aureus has many virulence factors. It is the staph to know. It causes skin and soft tissue infections, bloodstream infections, and joint infections. The other staphs, the coagulase-negative staphs, are also negative for many of *Staph. aureus*'s virulence factors.

Physiology/Structure. *Staph. aureus* is a gram-positive coccus that forms clusters. It is catalase positive and **coagulase positive**. *Staph. aureus* is **β-hemolytic**, and ferments mannitol on mannitol salt agar. Use caution, β-hemolysis is used to differentiate strep species, not staph species. But *Staph. aureus* could still be the answer if what they've given you is β-hemolysis. The defining characteristics that make *Staph. aureus* a staph species are clusters and catalase. The defining characteristic that makes the bug *Staph. aureus* is a positive coagulase test. No other gram-positive organism has coagulase.

Virulence. *Staph. aureus* has a number of virulence factors—protein A, coagulase, catalase, β-lactamase, and toxins. **Protein A** binds the Fc portion of IgG so that even though the antibodies bind to staph, the macrophages cannot bind to the Fc portion, allowing the bug to evade phagocytosis. **Coagulase** (the name coagulase makes it sound like it might lyse a clot, but it does the opposite) forms a fibrin clot around the organism, protecting it from phagocytosis. The fact that it is catalase positive means that it inherently resists the respiratory burst within phagocytes. There is **innate β-lactamase production**,

meaning that most penicillins don't work. So much so that we designed a narrow-spectrum penicillin specifically to compete with *Staph. aureus*'s β-lactamase. **Toxins** are discussed within the corresponding disease they cause, as described later in this section.

Methicillin is a penicillin used in the lab to assess the quality of that β-lactamase. If the *Staph. aureus* is resistant to methicillin, it is called methicillin-resistant *Staph. aureus* (MRSA). If the *Staph. aureus* is susceptible to methicillin, it is called methicillin-sensitive *Staph. aureus* (MSSA). Both forms have a β-lactamase, MRSA's is just better.

Epidemiology. *Staph. aureus* is part of the normal skin flora. Up to 25% of people are colonized with methicillin-resistant *Staph. aureus* (MRSA). Transmission between humans is through skin-to-skin contact—surgical wounds, unwashed hands in the hospital setting, or foreign bodies left in place. "Transmission" (from cohabitant microbe on the skin to disease-causing microbe beneath the skin) is almost always as translocation from the skin into the underlying tissue—penetrating trauma, such as IV drug use, diabetic foot wounds, or even just common scrapes or abrasions.

Diseases. Soft tissue infections: Cellulitis, skin abscess, and osteomyelitis. "Staph grows down, strep grows out." *Staph. aureus* causes skin infections very similarly to *Strep. pyogenes*. **Impetigo** (honey-crusted lesions of the skin) and **cellulitis** (well-demarcated erythema with increased warmth growing out from a central source in the skin) appear identical when caused by staph or strep. What makes *Staph. aureus* skin infections unique is the ability of *Staph. aureus* to burrow deep. **Skin abscesses** are almost always *Staph. aureus* and will erode tissue—muscle or bone. Because of this ability to erode, *Staph. aureus* is also the **most common cause of osteomyelitis**. *Staph. aureus* can also cause **septic arthritis**. If it erodes into bone, it is osteo; if it erodes into a joint, it is septic arthritis. Osteomyelitis and septic arthritis are easily explained by a penetrating injury through the skin with inoculation of the skin flora into the space, but they can also be caused by **transient bacteremia** with seeding of the deep tissues.

Gastroenteritis is a self-limiting disease that is caused by **ingestion of a preformed toxin**, aptly named **enterotoxins** A-E. Getting gastroenteritis from a preformed toxin does not constitute a gut infection with *Staph. aureus*. The preformed toxin causes the disease. As the toxins are already formed and ready to work, symptoms have a rapid onset. There will be nausea, vomiting, and diarrhea **2–6 hours after ingestion**. It is commonly found in proteinaceous or egg-based food that is left sitting out—mayonnaise, potato salad, and picnic foods. *Staph. aureus* in the food grows, produces preformed toxins in the food, then the food containing the toxins is consumed.

Scalded skin syndrome (SSS) is caused by a *Staph. aureus* infection and is a result of **exfoliatin toxin**. This causes the skin to slough off by disrupting the desmosomes. The site of infection does not correlate with the sloughing of the epidermal layer, it is merely a byproduct of a staph infection elsewhere. Desquamation and rash.

Toxic shock syndrome is caused by **toxic shock syndrome toxin 1** (TSST-1). This is a **superantigen** and, much like in SSS, results in a diffuse reaction caused by a local infection. Superantigens bind to and activate T-cell receptors without a specific MHC-II antigen presented. This allows widespread activation of T cells. This larger-than-usual activation of T cells produces an overabundance of inflammatory cytokines. These inflammatory cytokines then cause a systemic inflammatory reaction resulting in fever, hypotension, and death. TSST-1 is associated with an overgrowth of *Staph. aureus* on packing—**tampons** and **surgical packing**—that is not removed.

Pneumonia. When there is hospital-acquired pneumonia (HAP), ventilator-associated pneumonia (VAP), or health-care-associated pneumonia (HCAP), empiric coverage for MRSA is required. Staph-caused pneumonia should be suspected in one of three presentations. The first is a **superinfection**—an upper respiratory viral illness that gets better initially, then suddenly much worse, with new

consolidation on X-ray. The second is a pulmonary disease that begins as **pneumonia** and is **rapidly progressive** and **hypoxemic**. The third is an abscess formed by septic emboli that take up shop in the lungs. (This last isn't actually pneumonia, but an abscess caused by staph in the blood.)

Infective endocarditis is most commonly caused by *Staph. aureus*. This is not the subacute endocarditis with low-grade fevers, malaise, and subacute findings discussed below amongst the strep species. This is acute endocarditis often presenting with **high fevers**, **destruction of the valves** (presenting as a new regurgitant murmur), and overtly positive blood cultures that do not clear despite antibiotics.

Treatment. Empiric coverage for *Staph. aureus* infections in practice is with **vancomycin** because of the increased prevalence of MRSA. However, on your test, unless MRSA risk factors are strongly suggested, you can assume the *Staph. aureus* you have is **MSSA** (methicillin-sensitive *Staph. aureus*). **Nafcillin** is the intravenous drug of choice to treat MSSA, nafcillin being a narrow-spectrum (staph only) β-lactamase-resistant penicillin. For **MRSA**, treat with **vancomycin**. If there is vancomycin resistance (D-Ala-D-Ala to D-ala-D-lactate), options are with **linezolid** (but not for bloodstream infections) or **daptomycin** (but not for pneumonia). Community-acquired MRSA cellulitis can be treated with oral clindamycin or oral TMP-SMX.

Staph Not Aureus

Staph. saprophyticus (coagulase negative, novobiocin resistant, causes UTIs in newly sexually active women) and *Staph. epidermidis* (coagulase negative, novobiocin sensitive, infects catheters and shunts) are almost **exclusively contaminants**. Commonly seen on blood cultures that were not properly drawn (alcohol decontamination was ineffective), finding these organisms on culture usually results in their being ignored. When **one out of four bottles** is positive, it is a contaminant. When **four out of four bottles** are positive, it is a true infection (likely related to central venous catheters). In practice, these are effectively contaminants and need not be explored further.

Streps at a Glance

There are a lot of details, mechanisms, and diseases caused by strep species. Keeping the information in perspective, limiting the scope, helps prevent your getting lost. Use this image as a reference point. This overview image helps you see the forest and the trees.

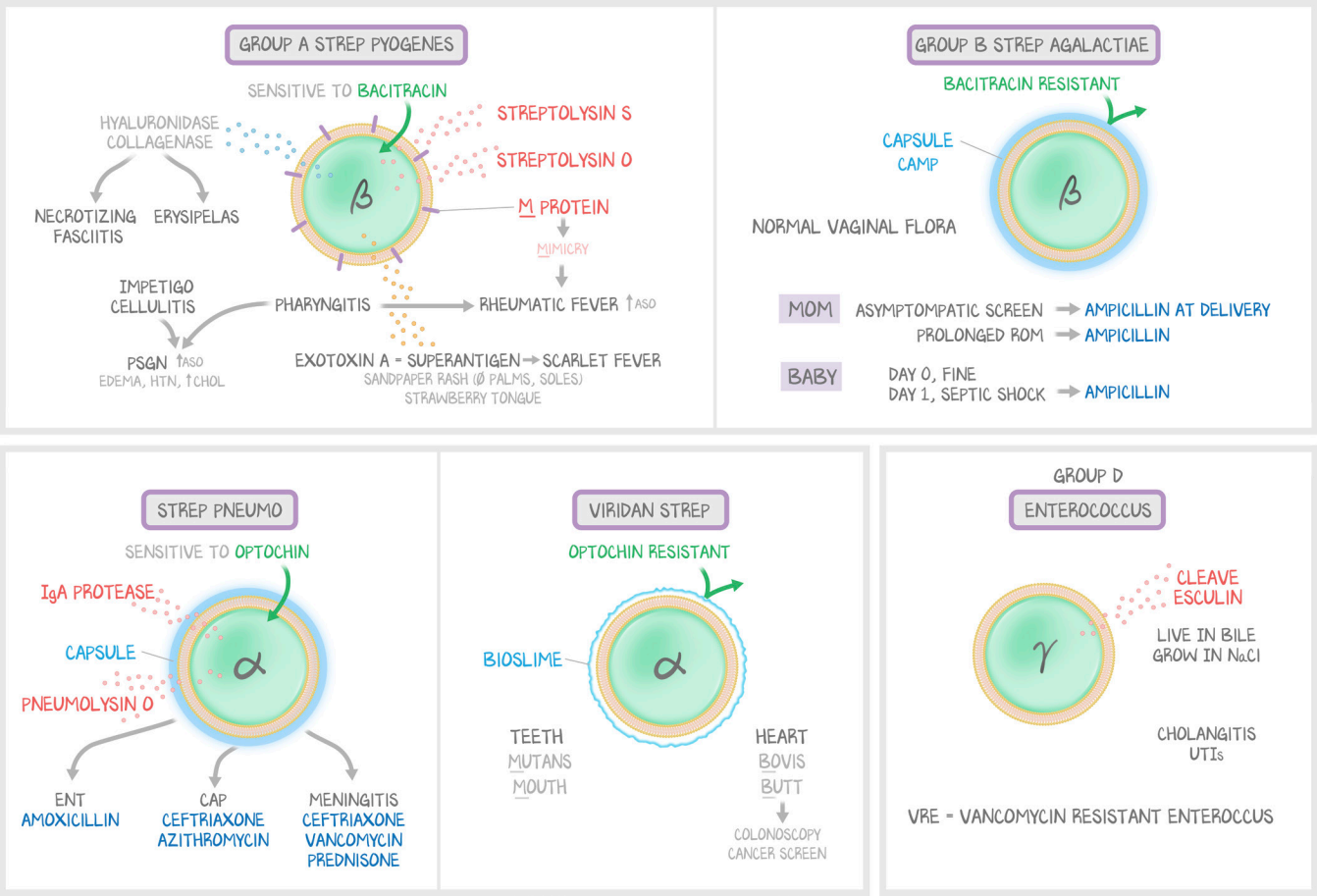

Figure 6.3: Streps at a Glance
This is a pictographic representation of the five strep species you need to be aware of. Each circle represents a single bacterium. Within the bacterium is the Greek letter that corresponds to the type of hemolysis it causes on blood agar, and they are grouped in order of that hemolysis. In red is the toxin they release that adds to their virulence. In green is their response to the differentiating antibiotic. In blue is whether they have a capsule of bioslime. Beneath each bacterium is the disease it causes, grouped by the organ system that disease occurs in.

Strep. pyogenes (aka Group A Strep)

Group A *Strep. pyogenes* is the strep infection that affects the skin and the throat. Skin strep (cellulitis, impetigo) and throat strep (strep pharyngitis) infections can lead to complications, sequelae of the infection in the way of rheumatic fever and post-strep glomerulonephritis (PSGN). Learn *"Group A Strep. pyogenes . . . first skin, throat . . . then kidneys and heart."*

Physiology/Structure. *Strep. pyogenes* is a **gram-positive coccus** and is **β-hemolytic**. The two strep species that are β-hemolytic are group A *Strep. pyogenes* and group B *Strep. agalactiae*; group A *Strep. pyogenes* is separated from group B *Strep. agalactiae* by their response to **bacitracin**—group A *Strep. pyogenes* is sensitive to bacitracin, and will not grow in its presence.

Virulence. Virulence of *Strep. pyogenes* can be broken down into "escapes" and "spreads."

Strep. pyogenes "escapes" host immune systems using hemolysins and antiphagocytic proteins. Streptolysin O and streptolysin S are hemolysins (cause lysis of red blood cells in vitro, causes the β-hemolysis on blood agar) and are, more importantly, cytolysins (they form pores killing or disabling lymphocytes in vivo). **Streptolysin O** is **oxygen labile** and **antigenic** (humans develop anti-streptolysin-O antibodies). **Streptolysin S** is **oxygen stable** and **non-antigenic**. The **M protein** is an **antiphagocytic** protein—it resists phagocytosis. The M protein is antigenic, and antibodies to the M protein are the causative agents in PSGN and rheumatic fever. Antibodies to M protein cause rheumatic fever; M protein is the antigen against which the disease-causing antibodies form. Clinicians assess for the presence of recent strep infection using the anti-streptolysin-O (ASO) titers, assessing for the presence of antibodies against streptolysin O.

Group A *Strep. pyogenes* "spreads" through tissue using the "-ases." This allows for a strep infection to spread in the horizontal plane of a tissue. This is where "staph grows down, strep grows out" comes from. Strep does not destroy local tissue, eroding into muscle or bone, as staph does. Instead, it separates the skin from the underlying connective tissue, and travels out in a plane along the skin. Streptokinase breaks down fibrin clots, DNase ("DNA-ase") liquefies pus, and hyaluronidase hydrolyzes the connective tissue, giving the infection room to spread. **Exotoxins A–C** are **superantigens** and cause the **fever and rash** of scarlet fever.

Diseases. Group A *Strep. pyogenes* is the **strep of cellulitis** but is also associated with **necrotizing fasciitis**. It is able to move through the tissue, spreading rapidly along the fascial layer. Group A *Strep. pyogenes* does not cause skin abscesses (that's staph). **β-lactams** work well; use macrolides if allergic.

Pharyngitis ("strep throat") and the more severe forms (peritonsillar abscess) are caused by *Strep. pyogenes*. Suspect strep throat when there are white purulent lesions, the absence of a cough, the presence of a fever, and tender lymphadenopathy in the anterior chain. Screening is done with a **rapid strep test** (ELISA), and confirmation is made with **culture** (though this is rarely needed). In the clinical sciences, you will be asked to determine whether a rapid strep test, culture, treatment, or reassurance can be offered based on the Centor criteria. You are not expected to do that for the preclinical sciences, only recognize the classic (all four features listed above) strep pharyngitis. **Scarlet fever** is pharyngitis untreated, leading to a **sandpaper rash** (also called a sunburn-like rash) that **spares the palms and soles**. There is also a **strawberry tongue** that is bright red and with many bumps. Treating strep pharyngitis with a β-lactam (amoxicillin) kills the infection and prevents sequelae.

Sequelae. Sequelae of group A *Strep. pyogenes* infections are rheumatic fever and poststreptococcal glomerulonephritis (PSGN).

Rheumatic fever is a possible consequence of **untreated pharyngitis only** (compared with PSGN). This is a type II hypersensitivity reaction. Antibodies against **M protein** exhibit antigenic mimicry against the endothelium of the heart valves, producing a stenotic lesion (discussed in detail in Cardiac: Plumbing #3: *Valves*). Rheumatic fever, during the event, is characterized by fever, joint pain, carditis, and erythema marginatum. Following the febrile arthralgias, chronic rheumatic heart disease is characterized by a stenotic valve. If exposed to group A *Strep. pyogenes* again, the reaction will occur again. Drawing anti-streptolysin-O antibodies (ASO titer) can ensure the diagnosis of a recent strep infection, but it is the M protein antibody that exhibits antigenic mimicry. **Treating strep throat prevents rheumatic fever.**

Poststreptococcal glomerulonephritis (PSGN) is another possible sequela of group A *Strep. pyogenes* infections. Whereas rheumatic fever is a product of pharyngitis, PSGN can be from either pharyngitis or cellulitis, and treating the strep infection is insufficient to protect against the development of PSGN. It is a type III hypersensitivity reaction, where the antigen-antibody complex is trapped in the

filtration slits of the glomerulus, leading to an immune response that destroys the glomerulus to get to the complex. ASO titers can be assessed, as well as anti-DNase B and antihyaluronidase, though these simply are markers of recent infection. The exact antigen that causes PSGN is unclear. PSGN is a self-limiting nephrotic syndrome characterized by edema, hypertension, and hypercholesterolemia.

Strep. agalactiae ("Pregnancy and Urine"), aka Group B Strep

Group B strep, GBS, and *Strep. agalactiae* all mean the same thing. Because they are synonyms, it is easy to get confused, thinking they are actually different organisms. That is why whenever we mention its name, we combine them to read group B *Strep. agalactiae*. This bacterium causes problems for babies delivered vaginally, and screening for group B *Strep. agalactiae* is part of routine prenatal care.

Physiology/Structure. Group B *Strep. agalactiae* is a **gram-positive coccus** and is β-hemolytic. It is separated from group A *Strep. pyogenes* by its response to **bacitracin**, group B *Strep. agalactiae* is resistant to bacitracin.

Virulence. Group B *Strep. agalactiae* has a **capsule**, is β-hemolytic, and has **CAMP factor** (CAMP, not cAMP).

Epidemiology and disease. Group B *Strep. agalactiae* is **normal vaginal flora** that only causes problems during **delivery**. Pregnant patients are screened for group B *Strep. agalactiae* with a third-trimester urinalysis. If positive, regardless of the presence of symptoms, the patient is treated with amoxicillin and rescreened. Normally, asymptomatic bacteriuria is neither treated nor tested for eradication; for pregnant patients infected with group B *Strep. agalactiae*, it is. Prophylactic ampicillin is administered at the time of delivery for prolonged rupture of membranes, a positive urine screen for GBS, or any positive group B *Strep. agalactiae* in any pregnancy. For patients who are not screened and not treated at delivery, group B *Strep. agalactiae* causes no prior problems—in fact, most group B *Strep. agalactiae* urine screens are asymptomatic. However, baby will have a **normal delivery** followed by **precipitous decline** and **septic shock**. The diagnosis is group B *Strep. agalactiae* neonatal septicemia. Intravenous penicillin (or ampicillin) is the treatment of choice. For GBS prophylaxis, intravenous intrapartum penicillin G is preferred (ampicillin for prophylaxis is often used, but is considered poor antibiotic stewardship). The slight difference between prophylaxis and treatment is because the neonate is often already very ill, so slightly broader antibiotics at the onset of treatment—with de-escalation as able—are often started first. In addition, many fewer neonates are treated for GBS septicemia than patients given intrapartum prophylaxis.

Strep. pneumoniae ("*Pneumoniae* in the Lungs Causes Pneumonia." Aka NO Group Letter)

Strep. pneumoniae ("*Strep. pneumo*") is an organism that causes mucosal diseases. It is responsible for otitis media (ear infection), sinusitis (sinus infection), pneumonia (where it gets its name from), and meningitis. *Strep. pneumo* has no Lancefield group designation. You should learn "*Strep. pneumo*, pneumonia, meningitis, ceftriaxone", and "*Strep. pneumo* also otitis/sinusitis, amoxicillin."

Physiology/structure. *Strep. pneumo* is a gram-positive coccus and is seen not in chains but as paired bacteria, described as **lancet-shaped diplococci** (this means it forms pairs). *Strep. pneumoniae* is α-hemolytic, separated from the viridans group by optochin sensitivity—*Strep. pneumo* is **optochin sensitive**.

Virulence. *Strep. pneumo* is **encapsulated**; the capsule is the most important virulence factor. It also has an **IgA protease** which cleaves IgA, allowing colonization of mucosa. **Pneumolysin O** (also called cytolysin or hemolysin) is released by the bacteria and forms **pores** in host cell membranes. This causes damage to ciliated cells of the respiratory epithelium. This killing of cells is what leads to the "rust-colored sputum" traditionally found in pneumonia patients on board exams. The color of sputum has

no likelihood ratio associated with a causative organism (in real life) nor even a diagnosis (in real life) though rust-colored sputum is code for *Strep. pneumo* pneumonia (on the test).

Epidemiology. *Strep. pneumo* is found in the normal flora of the upper respiratory tract. This means a patient could be colonized without infection, and any tip towards immunocompromise can provoke infection.

Diseases. Given the colonization in the upper respiratory tract and the IgA protease, it is not surprising that *Strep. pneumo* causes infections in the mucosa-containing organs. *Strep. pneumo* is the most common cause of **acute otitis media** and **acute bacterial sinusitis**. It is also the most common organism to cause **pneumonia** (chest X-ray consolidation, productive cough, and fever) with **blood-tinged rust-colored sputum**. Unexpectedly, *Strep. pneumo* is also the most common cause of **adult meningitis**, and is now also the most common cause of **neonatal meningitis** (a vaccine knocked *H. flu* out of the top spot for neonatal meningitis).

Treatment. When hospitalized, pneumonia is treated with both a **third-generation cephalosporin** (ceftriaxone, a β-lactam for the strep) and azithromycin (for atypical organisms). Mucosal infections are treated with penicillins (**amoxicillin** or amox/clav). Bacterial meningitis is treated with ceftriaxone, vancomycin, and steroids.

In addition, **vaccines** are available. The **adult vaccine** covers 23 of the most common serotypes to protect against pneumonia. The **pediatric vaccine** covers 13 common serotypes, preventing invasive disease. The serotypes reflect the varying polysaccharide antigens.

Viridans Strep ("*mutans* Teeth, *bovis* Colon." Aka NO Group Letter)

Viridans strep species are actually a variety of organisms. The only two that matter are *Strep. mutans* (teeth) and *Strep. bovis* (colon). We sometimes refer to it as Strep. viridans, even though it is not a species, it is a subgroup.

Physiology/structure. Viridans strep are gram-positive cocci and α-hemolytic. Viridans strep is separated from *Strep. pneumo* by response to **optochin,** viridans species are resistant.

Virulence. Viridans species excrete a dextran **bioslime** that both protects against phagocytosis and **increases adherence to teeth,** orthopedic **prosthetics** (hip, knee replacements), **and heart valves** (damaged or prosthetic). The bioslime is also what blocks the optochin from working.

Epidemiology and disease. *Strep. mutans* is part of the normal oral flora and is the bug responsible for **dental caries**. They cause plaque and cavities. These are not a big deal for most people—brushing and going to the dentist cleans your teeth. However, if a person has **damaged or prosthetic heart valves**, having dental work done can cause a transient translocation of *Strep. mutans* into the bloodstream, where it can adhere to those valves. This causes **subacute endocarditis**—subacute means no rupture of the valve and a long time to make the diagnosis. Malaise, fevers, night sweats, weight loss, Janeway lesions, Osler nodes, and splinter hemorrhages. *Strep. bovis*, now called *Strep. gallolyticus*, can do the same thing, only the translocation occurs in the colon, and is associated with colon cancer. If you see *Strep. bovis* (*Strep. gallolyticus*) bacteremia, perform a colonoscopy.

Enterococcus ("VRE in the Bladder." Aka Group D Strep)

Several *Enterococcus* species used to be classified as streptococci and considered part of group D strep, *Enterococcus faecalis* specifically. Since it is basically a strep organism, we sometimes refer to it as Strep Enterococcus. It is **very different** from strep species, however, in that it is a **gram-positive organism in the gut**. Gut bugs are usually anaerobic and gram negative. Enterococcus is the gram-positive organism that infects the belly and urine, and has gained attention because of the development of a vancomycin-resistant enterococcus.

Physiology/structure. *Enterococcus* bacteria are **gram-positive cocci**, have a variable hemolytic pattern (learn them as γ, no hemolysis), and are found to be PYR+. Enterococci **hydrolyze esculin in 40% bile** (bile esculin agar turns black). They can grow **in bile** or in **high salt**.

Virulence. Because they can hydrolyze bile, they tolerate bile, and so can **live in the bowel and gallbladder**. This makes them dangerous for manipulative bowel procedures. Because they can live in high-salt content, they are hard to kill. The development of vancomycin resistance makes them dangerous. Vancomycin-resistant *Enterococcus* (**VRE**) arises from the terminal pentapeptide used in transpeptidation of the cell wall. The terminal D-Ala-D-Ala binding site for vancomycin is replaced with D-Ala-D-Lactate, making vancomycin useless.

Diseases. *Enterococcus* should be seen as the gram-positive organism of the gut, causing the same infections as the gut bugs—colitis, diverticulitis, and **urinary tract infections**. Because *Enterococcus* can grow in bile, it can be the infectious agent in gallbladder diseases, especially **cholangitis** (see GI: Hepatobiliary #3: *Cholestasis*).

Treatment. VRE requires the use of linezolid or other "high-ladder" antibiotics (daptomycin, tigecycline, telavancin, as discussed in Antibacterials #3: *Cell Wall Inhibitors Not β-Lactams*).